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Prevalence of elongated styloid process on cone-beam computed tomographic images: a retrospective study

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ABSTRACT

Aims: The aim of the study was to evaluate the prevalence and the morphometric features of the styloid process (SP) via cone-beam computed tomography (CBCT).

Method: 400 SP of 200 individuals (92 males, 108 females, age range 12-81) were examined retrospectively in CBCT images in the axial, sagittal, and coronal planes. The measurements of SP and clinical and incidental findings associated with styloid ligament elongation (SPE) were detected. For descriptive statistics, the mean and standard deviation are given for numerical variables. The Mann-Whitney U test was used for measurements. The consistency of right and left SP lengths was analyzed for normality using the Shapiro-Wilk test ($p<0.05$).

Results: Males (55.7%) had a substantially higher prevalence of ESP than females (33.1%) ($p=0.032$). On the right side of the SP, the mean length was 26,76 mm (range: 8,7-63,3 mm), while on the left, it was 26,61 mm (range: 5,8-55,9 mm). 51 of them had bilateral lengths greater than 30 mm. The eight symptomatic patients' CBCT scans revealed SP sized anywhere from 36,6 mm to 69 mm on the right side. As incidental findings, soft tissue calsifications were detected in 5% of the 200 patients.

Conclusion: Men were found to have a higher prevalence of SPE than women, and a tiny percentage of cases were asymptomatic. There was no significant difference between right- and left-sided SP.

Key words: Calsification, cone-beam computed tomography, eagle syndrome

INTRODUCTION

The styloid process is an anatomical structure shaped like a cylindrical, thin, needle-like projection of varying lengths, averaging 2 to 3 cm.[1] It is classified as elongated if the measurement is more than 30 mm.[2] The styloid process (SP) projects from the inferior portion of the petrous temporal bone and offers attachment to the stylohyoid ligament and the muscles attached to the SP. Through these structures, SP facilitates the movement of the surrounding structures, such as the tongue, pharynx, larynx, hyoid bone, and mandible. Significant vessels and nerves surround the SP. The vena jugularis interna, arteria carotis interna, and some important cranial nerves lie medially to the SP. Arteria occipitalis and nervus hypoglossus run along its lateral side.[3]

The stylomastoid foramen, where the nervus facialis emerges from the skull, is directly posterior to the SP; however, it passes lateral to the process as it pierces through the parotid gland prior to splitting into its subsequent branches.[4,5]

The structure shows variations in length, angulation, and other morphological features between individuals. The length of the styloid processes might also be different bilaterally within the same individual.[6]

Multiple theories have been laid out as the etiology responsible for the variance in ossification and elongation of SP. The first theory is the "theory of reactive hyperplasia". The second theory is the "theory of reactive metaplasia,". The third theory is the "theory of anatomic variance." An additional and fourth theory is that the elongated styloid process is due to retained embryologic tissue from Reichert's cartilage.[7]

Although these theories explain the ossification and elongations in different ways, a consensus has not been established.

The frequent presence of an elongated styloid process (SPE) is estimated at around 4% of the general population. Compared to men, women are more likely to have SPE.[5]

SPE may be a result of various clinical symptoms, such as pain in the neck and cervicofacial area. Although these physiological differences are often found incidentally, some patients might develop a constellation of symptoms known as Eagle syndrome. The symptomatology of Eagle syndrome occurs secondary to irritation and/or compression of surrounding structures from an abnormal SP.[3]

Despite the fact that the majority of these individuals have no symptoms, a small percentage of those with SPE show

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symptoms and can present with one of two types of Eagle syndrome.[7,8]

Eagle syndrome presents itself with various degrees of symptoms, such as a sharp pain in the neck or the ear that extends to the maxilla, face, and oral cavity. Moreover, it might also be correlated with vertigo, tinnitus, or a sensation of something abnormal in the pharynx. Symptoms of classic Eagle syndrome are usually unilateral but can rarely present bilaterally. Pressure on the arteria carotis interna might present with symptoms of internal carotid vascular insufficiency such as weakness, visual changes, or syncope exacerbated with head movement. The SPE might also pose the risk of carotid artery dissection, resulting in a stroke or transient ischemic attack.[9]

The diagnosis of Eagle syndrome depends on the patient's clinical presentation, radiological investigation, and lidocaine infiltration test.[5]

For radiological investigations, a lateral head and neck X-ray, a Towne radiograph, can identify the SPE in two-dimensional imaging. Computed tomography (CT) allows for the radiological examination and measurements of the SP three-dimensionally.[10,11]

In the near past, three-dimensional cone-beam computerized tomography (CBCT) was a trustworthy imaging tool for anatomical structures of the maxillofacial region with high image quality, diagnostic accuracy, and sensitivity.[12,13]

The purpose of the present study was to appraise the size of the styloid process, the prevalence of an elongated styloid ligament, its relation to sex, location, and correlation between the right and left sides using CBCT images.

METHODS

The radiographic images of 200 individuals who had been referred to the oral and maxillofacial radiology department for CBCT examination from September 2021 to August 2022 were evaluated retrospectively.

In this retrospective study, 200 CBCT images of patients who were randomly selected and aged from 12 to 81 years were analyzed. The study was carried out in the Department of Oral And Maxillofacial Radiology of Lokman Hekim University's Faculty of Dentistry. All the CBCT examinations were acquired with Newtom VGI-Evo (NewTom, Verona, Italy) and reconstructed with NNT® software (NewTom®, v. 5.6.0) with a 0.300 mm axial pitch and 0.300 mm axial thickness. The measurements were accomplished utilizing InVivo Dental Application Version 5.2.3 (Anatomage, Santa Clara, USA). Only high-quality images were included in the study. Any radiograph with questionable SP and images of low quality, such as scattering or insufficient accuracy of bony borders, was excluded from the study. The study protocol, numbered 2022/201, was approved by the Scientific Research Ethics Committee at Lokman Hekim University. The study's protocol was carried out according to the principles described in the Declaration of Helsinki, including all amendments and revisions. The assessment of images was fulfilled directly on the monitor screen (a 23-inch Acer 1920 x 1080 pixel HP Reconstruction monitor).

Radiological measurements of 400 SPs were performed on CBCT images of the 200 patients by an oral and maxillofacial radiologist. The length and type of SP were recorded separately for each side since there were some differences between the right and left sides in the images. SP were assessed based on their average lengths. The length of the SP was recorded from the caudal margin on the tympanic plate to the tip of the process for each side. If the cranial part of the SP was not suitable for measurement, the length between the probable attachment point to the calvaria and the tip of the SP was recorded (14). The length of SP >30 mm was recorded as unilateral or bilateral elongation.[2,5-21]

Statistical Analysis

The consistency of right and left styloid process lengths obtained from the subjects was analyzed for normality using the Shapiro-Wilk test. Neither of the measurements was found to be normally distributed among the study group. The presentation of descriptive studies used average ± standard deviation, and median presentation. The differences between the ages of the subjects according to gender were analyzed using the Student's t-test. A Mann-Whitney U test was used to analyze the difference between right and left styloid process length according to gender. A Kruskal-Wallis variance analysis was used to compare right and left styloid process length according to age groups. Spearman's rank correlation coefficient was calculated for the correlation between age and styloid process lengths. SPSS (version 21.00 for Windows. SPSS Inc., Chicago, IL, USA) was used for statistical analysis. ($p < 0.05$)

RESULTS

A total of 200 individuals, 108 women and 92 men, between the ages of 12 and 81, with a mean age of 41,32±18,76 were selected for the research. (**Table 1**)

Table 1. Descriptive Analysis

	N	Minimum	Maximum	Mean	Std. Deviation
Age	200	12	81	41.32	18.769
Valid N (listwise)	200				

Examination of CBCT images demonstrated that the mean length of the styloid processes was 26,7 ± 8,3 mm (range: 8.7-63.3 mm) on the right side and 26,6 ± 7,7 mm (range: 5,8-55.9 mm) on the left side. The prevalence of ESP was significantly higher in males (55.7%) than females (33.1%). The consistency of right and left styloid process lengths obtained from the subjects was analyzed for normality using the Shapiro-Wilk test ($p = 0.032$). (**Table 2**).

Table 2. Test of Normality

Gender	Shapiro-Wilk		
	Statistic	df	Sig.
Female	.900	108	.32
Right ligament			
Male	.941	92	.169
Female	.842	108	.002
Left ligament			
Male	.931	92	.096

The results for the ligaments on each side were similar in both genders. ($p=0.176 > 0.05$) (**Table 3**)

As incidental findings, 10 of 200 individuals had soft tissue calsifications. (**Figure 1**)

51 of the styloid processes were longer than 30 mm bilaterally. (**Figure 2**)

Table 3. Paired Samples Test for SP between right and left side

	Mean	N	Std. Deviation
Right ligament	26.768	200	8.3125
Pair	26.613	200	7.7162
Left ligament			.176

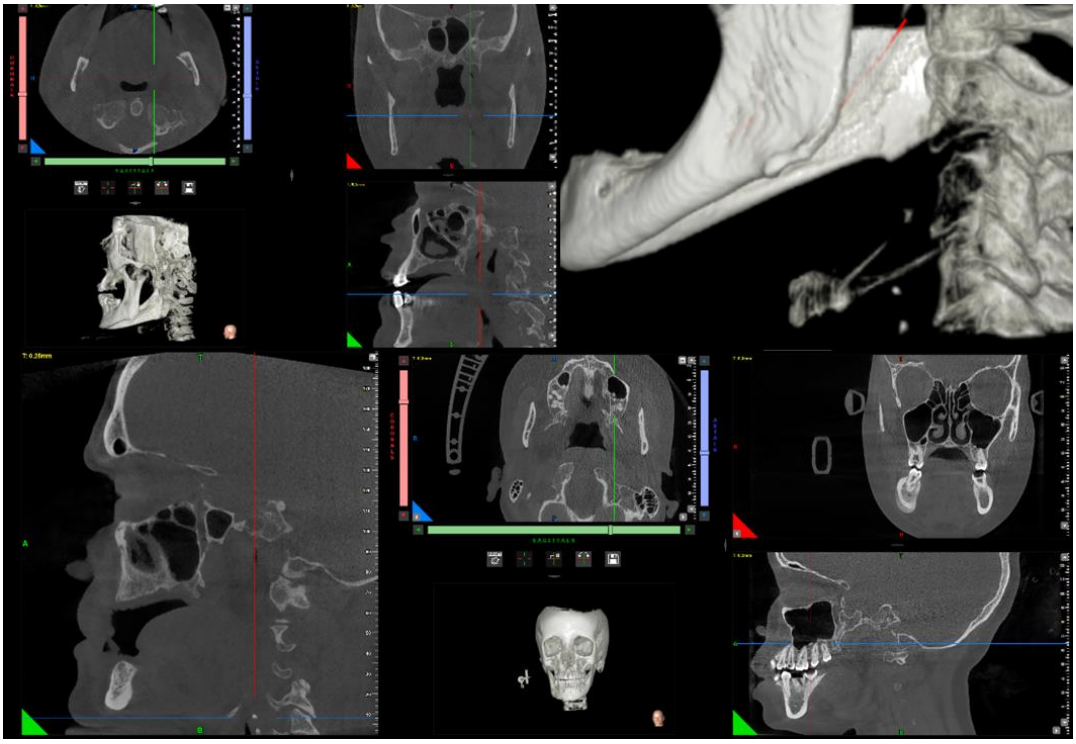

Figure 1. CBCT Image of soft tissue calsifications. Tonsillolith, carotis artery calsifications, anthrolith.

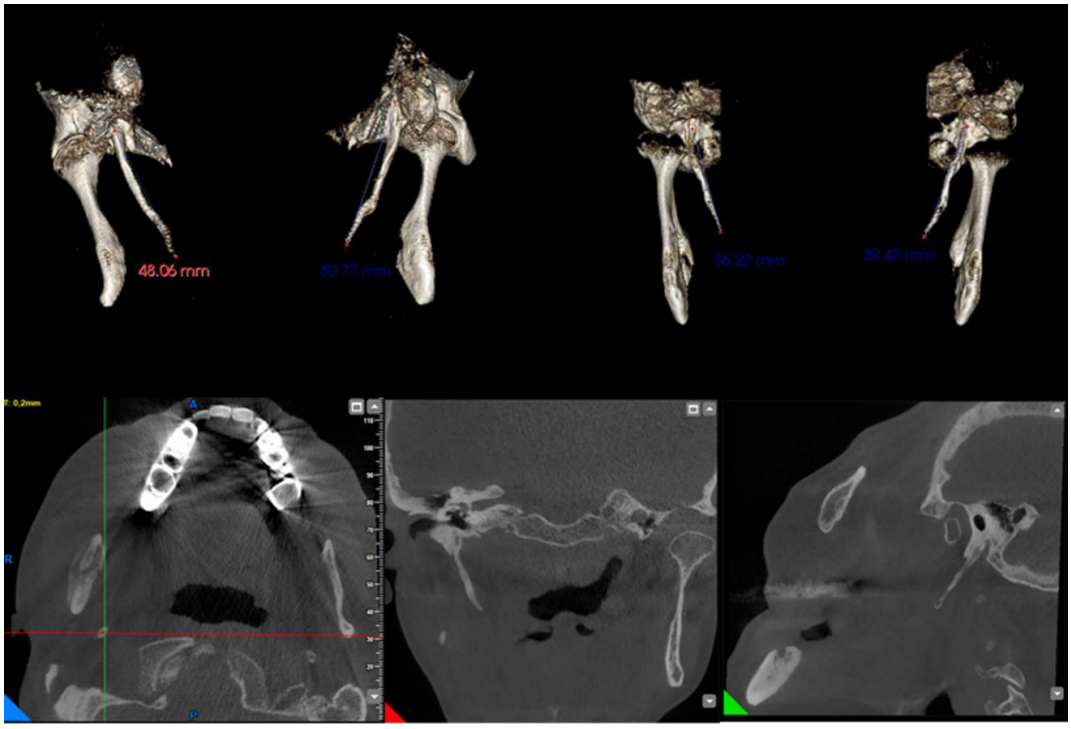

Figure 2. Coronal, axial and sagittal views of CBCT image.

Only eight patients were symptomatic. The CBCT images of the symptomatic patients showed styloid processes measuring at least 36,6 mm to 69 mm on the right side. (**Figure 3**)

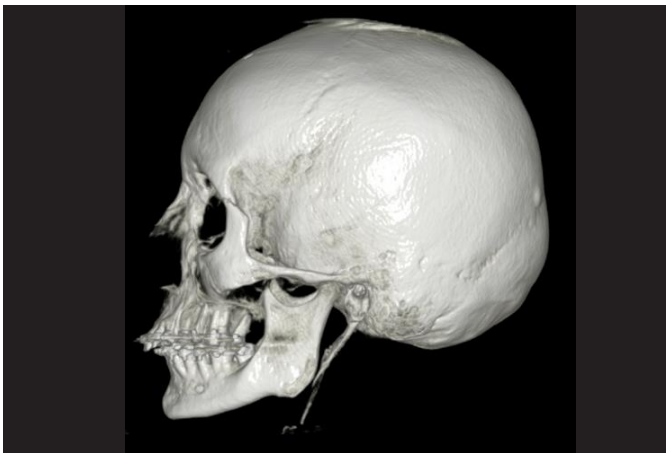

Figure 3. CBCT image of a SP measuring 69 mm.

DISCUSSION

There are several variations of features of the SP, such as the length, the degree of ossification, the distrubution between genders, and the right and left sides.[22]

The hyoid smaller horn, SP, and stylohyoid ligament are formed from Reichert's cartilage during the development of the head and neck region. In some cases, ossification of the stylohyoid ligament occurs and leads to the formation of SPE. The definition of Eagle's syndrome is symptomatic lengthening of the SP or calcification of the stylohyoid and stylomandibular ligaments.[15]

Physical examination and radiographic analysis are both used to make a diagnosis. There are several radiographic techniques used in dentistry to diagnose SPE, such as orthopantomographs and cone beam computed tomography.[21,22,23-26]

In this study, CBCT images of 200 individuals were examined. Only a tiny part (between 4% and 10.3%) of those with SPEs, who represent roughly 4% of the population, are considered to show symptoms.[27]

Öztunç et al.[23] compared elongated SP and without elongated SP on CBCT images and found the mean age of the patients with SPE to be 47.28 ± 12.4 years. In this study, the mean age of the patients with SPE was 41,32 ± 18,76 years (range: 12–81 years), and similar to this, all of the symptomatic patients were older than .[40]

Similar to this study, other studies have found that the mean SP length was significantly different between males and females. The prevalence of SPE was higher in males than females.[21,25,28]

Camarda et al.[29] measured the mean length of the SP in their study, and it was similar to this study. And also, the values of both sides were found to be close to each other, similar to the present study. There was no difference between both sides in both genders in the present study.

Jung et al.[30] examined panoramic images of 1000 patients and reported that both sides' distributions are similar and do not significantly differ (Kolmogorov–Smirnov test, P= 0.380). Although the examined image technique differs between 2 and 3 dimensions, both studies showed similar results.

Clinical complaints of SPE are related to the size of the stylohyoid complex.[19] In this study, the CBCT images of the eight symptomatic cases showed SP measuring at least 36,6 mm to 69 mm on the right side. Camarda et al.[19] reported that patients experiencing symptoms tended to be older than 40 and had no recent history of cervicopharyngeal trauma, tonsillectomy, or other surgery. Nobody among our symptomatic individuals had ever undergone surgery or experienced trauma.

Soft tissue calsifications such as tonsilloliths, antroliths, and carotid artery calsifications were detected as incidental findings.

Missias et al.[31] detected soft tissue calsifications in CBCT images with different fields of view. SPE and tonsillolith were the most frequent calcifications in their study. Pette et al.[32] evaluated the prevalence of soft tissue calcifications in 318 samples and reported that tonsillolithes and antrolithes were common with a range of 32% and 3%, respectively. Price et al.[33] evaluated incidental findings in the maxillofacial region by CBCT and reported tonsilloliths, antroliths, and carotid artery calcifications at 43%, 5%, and 13% in CBCT scans of 300 individuals, respectively.

In the present study, 10 of 200 individuals had soft tissue calsifications. Tonsilloliths (4 of 10 individuals) located on the right side of the lateral wall of the pharynx were sized at 0.8mm, 1,8 mm, 1,4 mm, 1,3 mm, and 0,7 mm in diameter. Soft tissue calsifications (3 of 10 individuals) located in the laryngopharynx sized 1,7 mm, 0,8 mm, and 0,5 mm in diameter. Antrolith (1 of 10) sized 2 mm in diameter and mucosal thickening consistent with maxillary sinusitis. The elongated styloid process might also compress the carotid artery. In this study, a CBCT image showed carotid artery calcifications (2 of 10 individuals) sized 2,0 and 2,2 mm in diameter.

CONCLUSION

In this study, morphometric examination of the styloid process, clinical complaints, and potential incidental findings were all assessed using CBCT images. While the prevalence of SPE was found to be higher in men compared to the female population, no significant difference was found for right- and left-sided SP.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study protocol, numbered 2022/201, was approved by the Scientific Research Ethics Committee at Lokman Hekim University.

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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